Gravitational Lenses (Lecture Notes in Physics, Vol 330)

(Proceedings of a Conference held at the Massachusetts Institute of Technology, Cambridge, Massachusetts, in honour of Bernard F Burke's 60th Birthday, June 20, 1988)
edited by J M Moran, J N Hewitt and K Y Lo
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This is a volume of articles based on the papers presented at the 60-th Birthday Conference in honour of Professor Bernard Burke, held at the Massachusetts Institute of Technology, in June 1988.

It is usually argued that conference proceedings of this type contain nothing new, that all papers presented there are published in established journals and that by the time the book appears the articles in it are out of date anyway. There is some truth in the argument and it could be used against the collection presented here. However there is the other side to the coin, also applicable to this volume. It is as follows.

When a conference is convened in honour of a pioneer in the field, it brings together a good cross section of the active workers to talk about the state-of-the art in that field. Supporting and opposing points of view are reflected in the articles and one gets a comprehensive view of the topic of the conference that is not provided by reading isolated articles published in different journals at different instants of time.

Although the idea of gravitational bending of light was concretised by general relativity and inspired the famous eclipse studies of 1919, the subject of gravitational lenses really 'caught fire' in 1979 with the discovery of the twin quasars 0957+561 AB. Identical redshifts and spectroscopic similarities prompted the hypothesis that A and B were two images produced by an intervening gravitating object, of *One* QSO.

Was this a flash in the pan or a common occurrence ? Other candidate pairs, even triplets have since turned up. There have been different observational checks on the various lensing models. These proceedings describe the overall picture in different sections.

Section I naturally outlines the career of Bernie Burke and his contributions to the field of gravitational lensing. In the next section there is the historical account of the discovery of 0957+561, by one of the discoverers, D Walsh. This is followed by another historical paper by J Bernothy who was advocating a search for gravitationally lensed QSOs long before the discovery of 0957+561.

Section III has five papers on the optics and modelling of lens systems, followed by seven papers discribing observational status in section IV. In section V, there is a discussion of luminous arcs found largely in clusters of galaxies. With accumulating data, the need for systematic surveys, searches and statistics crops up and section VI is devoted to these. Finally, the more recent work on microlensing is described in section VIII.

Twenty eight articles based on a one-day meeting are served in a compact from. Some articles are extremely short having been based on poster papers. These are negative points as also is the lack of any discussion that must have taken place after the talks. Nevertheless, the entire collection may be considered a fair representation of what is currently going on in the field of gravitation lensing.

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An Introduction to the Numerical Analysis of Spectral Methods (Lecture Notes in Physics, Vol 318)

by Bertrand Mercier

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In recent times, a lot of research activity goes on in the study of Spectral Methods, which is an approach to find approximate solutions to partial differential equations. In this approach, we try to approximate the solution by means of a truncated series of special functions which are usually eigenfunctions of some differential operator.

The book provides an easily readable introduction to this subject. It must be emphasized that it is only an introduction. No monograph of this size can do more than that. Also as pointed out in the editorial preface, the more recent developments have been left out.

The book is divided into two parts. The first part provides a good review of Fourier series, sine series and cosine series. The notion of a periodic distribution is introduced and some properties of periodic Sobolev spaces are studied. This frame work is then used to study some evolution equations with periodic boundary conditions. The error estimates for the Galerkin approximation are obtained and the method is shown to be of "spectral accuracy", i.e. the order of convergence depends only on the smoothness of the data. The interpolation operator is studied and the properties are used to carry out the error analysis for the collocation, or, pseudo-spectral method. Finally, the Fourier approximation of a stationary (elliptic) problem with periodic boundary conditions is studied.

The second part deals with polynomial expansion methods, with a view to studying problems with boundary conditions which are not periodic. Special emphasis is given to Chebychev expansions which permit the interpolant of the solution to be easily computed using the Fast Fourier Transform. Again the study of the orthogonal projection operator permits us to carry out the error analysis for the approximation of some evolution equations including the heat equation with variable coefficients.

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An Introduction to Riemann Surfaces, Algebraic Curves and Moduli Spaces
(Lecture Notes in Physics, Vol 322)
by M Schlichenmaier

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xiii+148 pages ; price : DM 39 (Hard cover) ; ISBN 3-540-50124-x

The close links between Riemann surface theory and physics go back to Riemann himself, who, according to Felix Klein, used electrical and hydrodynamical analogies to develop his ideas. Over the years, the subject has found application in mechanics, hydrodynamics, electrodynamics and, more recently, in statistical mechanics, in problems either set in, or reducible to, two dimensions.

Since string theory is a two dimensional theory, it is not surprising that Riemann surfaces play a role. What is surprising is that it is the more recent developments in the subject, even results obtained as a consequence of the Grothendieck revolution in algebraic geometry, which are of interest.

The primary aim of the book under review appears to be to discuss the Belavin-Knizhnik theorem in string theory and explain its relationship to the Mumford isomorphism. This requires introducing the Grothendieck-Riemann-Roch (G-R-R) theorem. This is the last section § 10. A second aim is to introduce the Krichever-Novikov (K-N) algebra, a higher genus analogue of the Virasoro algebra. The K-N algebra is a research interest of the author and I recommend § 9(b) to anyone interested in the subject.

To get to the material of § 10 usually takes the student of algebraic geometry about three years of hard work. The author has attempted to provide the physicist with a quick route to these results and in consequence many results, important even for the physicist, are dropped.

In § 1, 2 and 4 the author gives an outline of complex geometry and topology in two dimensions. Those with some familiarity with differential geometry will breeze through this part. Special mention should be made of § 2 on homotopy and homology theory. § 3 contains a brief discussion of function theory and the Riemann-Roch (R-R) theorem without using the language of line bundles.

In § 5 and § 6 the author tries to give a flavour of algebraic geometry with a description of the Jacobian as a projective variety. This is not strictly relevant for what follows. In § 7, a brief, but clear and useful, description is given of the moduli space of curves.

From § 8 the level of abstraction rises with a 15 page introduction to vector bundles and sheaf cohomology. This is applied in § 9 to restate the R-R theorem in terms of line bundles and this in turn is applied to the K-N algebra.

In § 10 the author introduces higher direct image sheaves, the Mumford isomorphism and the G-R-R theorem. Those who have previously tried to grasp this material will find the account given here useful, but the neophyte might find it difficult to follow. The book ends with an appendix giving a brief summary of p-adic numbers, which enjoyed a brief vogue in string theory a couple of years ago.

While the book is undoubtedly useful, it should not be imagined that one can start using algebraic geometry in string theory or conformal field theory after reading it. Indeed, virtually none of the techniques of algebraic geometry that I have found useful in my own research work are to be found here. In addition, the lecture notes origin of the book is obvious and makes for an uneven level in what is expected from the reader. The best way to use the book would be to ask a friendly mathematician to give lectures based on it which is how the book was written in the first place !

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The Spinorial Chessboard (Trieste Notes in Physics)

by P Budinich and A Trautman

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viii+128 pages ; price : DM 45 (Soft cover) ; ISBN 3-540-19078-3

One of the many conceptual difficulties that a beginning student faces in studying quantum mechanics is in understanding the peculiar behaviour of a spin $\frac{1}{2}$ particle under 2π rotations. The mathematical description of this behaviour in terms of spinors, which unlike the more familiar vectors and tensors, change sign under 2π

rotations, often lead the student to wonder why there are not objects invariant only under $2N\pi$ rotations for every N! The fact that spinors exist because $\pi_1(SO(3)) = \mathbf{Z}_2$ is discussed only later, if at all. Dirac, with his remarkable physical insight, devised an ingenious illustration of invariance under only 4π rotations by attaching a pair of scissors to a fixed support with three strings. The mathematical proof that this experiment indeed depends on $\pi_1(SO(3)) = \mathbf{Z}_2$ came much later and used Artin's theory of braid groups !

It used to be the practice for the particle physicist to avoid having to learn more about spinors then was necessary to understand the Dirac and Weyl equations, in spite of the existence of the quite readable 1935 paper of Brauer and Weyl on *Spinors in n dimensions*. This attitude, reminiscent, perhaps, of the 19th century physicist treating as irrelevant the plea that vectors were superior to quaternions since they could be generalized to n dimensions, is no longer possible with developments in the last 20 years such as dimensional regularization, grand unified theories, Kaluza-Klein theories and string theory. The book of Budinich and Trautman contains much that a physicist working in such areas needs to know, but which it is not easy to locate in the literature.

The book is on the algebraic theory of spinors and thus primarily on the Clifford algebras. The first chapter gives a history of the subject as well as a survey. It may seem somewhat daunting to many readers, but it can be skipped, though at the cost of missing such a gem as a spinor description of the problem of constructing Pythagorean triples !

After a summary of basic definitions in chapter 2, the next two chapters give a simple, but careful treatment of vector spaces, algebras and representations. Attention should be drawn to the detailed treatment of Schur's lemma. Graded, i.e. super, algebras are also introduced briefly.

The next three chapters constitute the real heart of the book. Chapter 5 gives a general discussion of Clifford algebras and it is only in chapter 6, on complex Clifford algebras, that we finally come across Dirac and Weyl spinors, though in n dimensions.

The last chapter is on real Clifford algebras. The particle physicist will find the careful discussion of charge conjugation and Majorana spinors of interest, while the mathematicians will find useful the discussion of Clifford algebras in Euclidean space. We finally meet in this chapter the '*spinorial chessboard*' of the title : a table summarizing the mod 8 periodicity properties of real Clifford algebras.

This book could be read with profit by graduate students, or even interested MSc students, in physics having an inclination towards mathematical physics.

The expert too will find it a very useful source of information, which it is otherwise difficult to find.

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Applications of Self Adjoint Extensions in Quantum Physics (Lecture Notes in Physics, Vol 324)

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edited by P Exner and P Seba

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This is a proceedings of a Conference held in Dubna, USSR, in 1984. It deals with contact interactions and rigorous mathematical procedures to handle such interactions which has a defacto recognition in many branches in physics. A number of important contributions, some by experts in the line, bear out the essential problems in theory involved and their solutions as self-adjoint extensions of suitable operators and construct quantities of physical interest. Different aspects of the problem arising out of varied nature of problems dealt with, starting from wave guide, few body problem to quantum field theory, are well borne out and the objective of the Conference is essentially achieved.

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